A. FRONT COVER/TITLE PAGE

TITLE OF RESEARCH PROJECT:

ASSESSING THE EFFECTS OF SOIL HUMIC AND FULVIC ACIDS
ON GERMINATION AND EARLY GROWTH
OF NATIVE AND INTRODUCED GRASS VARIETIES

NAME OF PRINCIPAL INVESTIGATOR: SENESI NICOLA-PROFESSOR

NAME OF CONTRACTOR: UNIVERSITA' DI BARI

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FINAL REPORT

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END OF FRONT COVER/TITLE PAGE

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B. SUMMARY OF THE RESEARCH PERFORMED AND CONCLUDING COMMENTS

1. Possible relationships between the germination and seedling growth data and the chemical and spectroscopic parameters of the HAs examined

The presence of humic acid (HA) generally affects positively and at various extent the germination and early growth of all varieties examined but in some cases negative effects are measured on the early growth. However, the response of the species varieties, examined either singularly or in combination by two, does not show any specific trend as a function of either the type or concentration of HA.
This result can be ascribed to the fact that the three HAs used for the germination and early growth experiments do not show any significant differences in their compositional, functional and structural parameters determined by chemical methods and spectroscopic techniques
Thus, it is impossible to find out any direct relationship between HA chemical and physico-chemical parameters, or concentration, and germination and growth response of the four varieties examined either singularly or in combination by two.

2. The effects of HA on each variety grown alone

Although, with respect to the controls, and as a function of HA type and concentration, non significant differences are generally measured for the germination % of the four varieties, the primary root and shoot lengths of germinated seeds show significant or highly significant differences. In conclusion, the three HAs at both concentrations appear to exert a general slight promoting effect on the germination of the four varieties considered separately. Among these, the effect is generally more pronounced for the germplasm lines SERDP-select Slender and Siberian than for the cv. Pryor Slender and cv. Vavilov Siberian.
With respect to the controls, the presence of HA generally promotes the early growth of the cv. Pryor Slender and the germplasm line SERDP-select Siberian, whereas that of the germplasm line SERDP-select Slender is unaffected or, in some case, reduced, and that of the cv. Vavilov Siberian is generally reduced.

3. The effects of HA on varieties grown in combination of two

3.1. **COMBI-A (SERDP-select Slender and cv. Vavilov Siberian)**
In general, the presence of HA increases the germination % of SERDP-select Slender more than that of the cv. Vavilov Siberian, whereas the opposite effect is exterted on primary root and shoot growth.
Almost all HA treatments depress the early growth of both varieties.
3.2. **COMBI-B (SERDP-select Slender and SERDP-select Siberian)**
In general, the presence of HA reduces slightly the germination of SERDP-select Slender and promotes that of SERDP-select Siberian.
Diffrently, the early growth of both varieties is generally promoted by HA treatments, more for the SERDP-select Siberian than for the SERDP-select Slender.
3.3. **COMBI-C (cv. Vavilov Siberian and SERDP-select Siberian)**
The HA treatments generally increase the germination % of SERDP-select Siberian and primary root length of both varieties, whereas they reduce the germination % of cv. Vavilov Siberian and primary shoot elongation of both varieties.
Differently, the early growth of both varieties is generally promoted by HA treatments, more for the SERDP-select Siberian than for the cv. Vavilov Siberian.

3.4. **COMBI-D (cv. Pryor Slender and SERDP-select Slender)**

In general, HA treatments appear not to influence statistically the germination parameters of both varieties, but promote the germination of SERDP-select Slender with respect to that of cv. Pryor Slender, whereas the opposite effect is apparent for early growth.

3.5. **COMBI-E (cv. Pryor Slender and cv. Vavilov Siberian)**

The HA treatments generally appear to favor germination of cv. Vavilov Siberian more than that of cv. Pryor Slender, whereas the opposite effect is apparent for early growth.

3.6. **COMBI-F (cv. Pryor Slender and SERDP-select Siberian)**

The HA treatments generally appear to promote the germination % of cv. Pryor Slender more than that of SERDP-select Siberian, whereas the opposite occurs for primary root and shoot lengths.

On the contrary, the early growth of both varieties appear to be generally depressed by HA treatments.

LIST OF KEYWORDS

Wheatgrass varieties, cv. Pryor Slender, germplasm-line SERDP Slender, cv. Vavilov Siberian, germplasm-line SERDP Siberian, seed germination, primary root, primary shoot, seedling early growth, shoots length, roots length, shoots weight, roots weight, Dugaway soil, Guernsey South soil, Guernsey North soil, humic acids,elemental composition, Fourier transform Infrared (FT IR) spectroscopy, fluorescence spectroscopy.

LIST OF PUBLICATIONS RELATED TO THIS RESEARCH

N. Senesi, E. Loffredo, A. J. Palazzo, C. E. Clapp. 2007 Germination and early growth of two introduced varieties of Siberian wheatgrass. ASA-CSSA-SSSA Annual Meetings, New Orleans, November 2007.

A number of publications are in preparation based on results of this research.

C. BODY OF THE REPORT

(1) SCIENTIFIC WORK DONE DURING THE REPORTING PERIOD

1. Germination and Early Growth of the wheatgrass varieties grown together in combinations of two

1.1. Experimental

1.1.1. Combinations of wheatgrass varieties

The germination and early growth response of the four varieties of interest were tested in experiments where two varieties were grown together (in combination) each time.
The second set of experiments were performed using the combinations: (a) the **cv. Pryor** of the native species **Slender wheatgrass** and the germplasm line **SERDP-select** of the native species **Slender wheatgrass (COMBI-D);** (b) the **cv. Pryor** of the native species **Slender wheatgrass** and the **cv. Vavilov** of the introduced species **Siberian wheatgrass (COMBI-E)**; and (c) the **cv. Pryor** of the native species **Slender wheatgrass** and the germplasm line **SERDP-select** of the introduced species **Siberian wheatgrass (COMBI-F)**.
In order to have comparable results, the germination and early growth of these combinations were studied using the same three HA samples (**GN-HA**, **GS-HA** and **D-HA)** at the same concentrations of 10 and 100 mg/L and in the same conditions used in the previous sets of experiments performed either (1) with the four grasses grown separately (results described in Reports n.1 and n.2); or (2) with the combinations: (a) the germplasm line SERDP-select of the native species Slender wheatgrass and the cv. Vavilov of the introduced species Siberian wheatgrass (COMBI-A); (b) the germplasm line SERDP-select of the native species Slender wheatgrass and the germplasm line SERDP-select of the introduced species Siberian wheatgrass (COMBI-B); and (c) the cv. Vavilov of the introduced species Siberian wheatgrass and the germplasm line SERDP-select of the introduced species Siberian wheatgrass (COMBI-C) (results described in previous Report n.3).

1.1.2. Germination experiment

A procedure identical to that described in the previous Report n.3 for COMBIs A, B, and C, was used. The seeds were preliminary surface-sterilized by dipping them for 15 min in sodium hypoclorite 0.2 %, and then washing several times with distilled water. Ten (10) seeds of each two-variety combination were placed in the same Petri dish on filter paper, and added with suspensions of each HA at each concentration in distilled water, or with distilled water only (control). In order to allow the free circulation of the germination medium in the dish and, at the same time, keep the seeds of the two varieties separated, a plastic net having small holes was put across the dish. The Petri dishes were kept in the dark for 6 days in a thermostated chamber at a temperature of 20 °C. After this time period, germinated seeds were removed and counted, and the lengths of the primary root and shoot were measured. All the experiments were replicated five (5) times.

1.1.3. Early growth experiment

A procedure identical to that described in the previous Report n.3 for COMBIs A, B, and C, was used. After the end of the germination experiment and after collection of germination data, the germinated seeds (seedlings) of the two varieties of each combination were inserted into holes of

aluminum lids placed on the top of glass pots (3 seedlings of each variety per pot). In order to allow the free circulation of the growth medium in the pot and, at the same time, keep the roots of the two varieties separated, the pot was vertically divided in two parts with a plastic net having small holes. The pots were filled with the Nitch nutrient solution, in the absence (control) or presence of each HA at concentrations of 10 and 100 mg/L. The pH of the nutrient solution was preliminary adjusted to 6.5 with a solution of NH_4OH. Blanks (without seedlings) were also prepared for each treatment in order to measure the pH change during the growth period in the absence of plants. The pH of all treatment media ranged between 6.5 (control) and 5.9 (GS-HA at 100 mg/L). The pots were then placed in a Phytotron growth chamber, and seedlings were allowed to grow for a period of 21 days in the following conditions: (a) photoperiod of 12-h; (b) temperature of 20 °C and humidity of 74% during the illumination period; and (c) temperature of 17 °C and humidity of 70% during the dark period. At the end of the experiment, the pH of the growth solutions and blanks, and the length and fresh and dry weights (60 °C for 48 h) of roots and shoots were measured. All experiments were conducted in five replicates.

1.1.4. Statistical analyses

All germination and growth data were analyzed statistically by one-way analysis of variance (ANOVA) and the means of the treatments were separated by the least significant difference (LSD) test.

1.2. Results and Discussion

1.2.1. Germination data

Statistical treatment of data by ANOVA shows, with respect to the corresponding controls, and as a function of either the HA type or HA concentration, the existence of: (a) a significant difference only in the case of primary root and shoot lengths of SERDP-select Slender in **COMBI-D (Table 1)**; (b) a significant or highly significant difference, in the germination and primary shoot and root lengths of cv. Vavilov Siberian, and a significant difference of primary root length of cv. Pryor Slender in **COMBI-E (Table 2)**; (c) a significant or highly significant difference in the germination and primary root length for both varieties in **COMBI-F (Table 3)**. No significant effects are measured in the other cases.

COMBI-D

Numerical data in **Table 4** show that, with respect to the control, no HA treatment influences statistically the germination % of either varieties. Data in **Fig. 1** (top) show that in the presence of any HA at any concentration, except for GN-HA at 100 mg/L, the number of germinated seeds of SERDP-select Slender is slightly greater than that of cv. Pryor Slender.
Numerical data in **Table 7** show that, with respect to the control, only D-HA at both concentrations and GS-HA at 100 mg/L increases significantly the primary root length and GS-HA at 100 mg/L the primary shoot length of SERDP-select Slender. Data in **Fig. 2** (top) show that the three HAs examined at both concentrations have variable and slidght effects on the primary root and shoot lengths of the two varieties grown together, with the exception of GS-HA at 100 mg/L that apparently promotes the primary shoot length of SERDP-select Slender with respect to that of cv. Pryor Slender.

COMBI-E

Numerical data in **Table 5** indicate that, with respect to the control, only the germination % of cv. Vavilov Siberian is increased significantly by GS-HA at both concentrations. Data in **Fig. 1** (middle), if compared to the control, show that the number of germinated seeds of cv. Vavilov Siberian increases more than that of the other variety, cv. Pryor Slender, only in the presence of GS-HA at 100 mg/L.
With respect to the control, the primary root length of cv. Vavilov Siberian is increased highly significantly or significantly in any HA treatment and the primary shoot length only by D-HA at 100 mg/L and GS-HA at 10 mg/L, whereas the primary root length of the other variety, cv. Pryor Slender, is increased significantly only by D-HA and GS-HA at 10 mg/L and GN-HA at 100 mg/L **(Table 8)**. Data in **Fig. 2** (middle) show that, with respect to the controls, the primary root length, in the presence of any HA at any concentration, and the primary shoot length, in the presence of D-HA at both concentrations and GS-HA at 10 mg/L, of cv. Vavilov Siberian increase more than that of the other variety, cv. Pryor Slender.

COMBI-F

Numerical data in **Table 6** indicate that, with respect to the control, the germination % of cv. Pryor Slender is increased significantly by the three HAs at either 10 mg/L (D-HA and GS-HA) or 100 mg/L (GN-HA), whereas that of SERDP-select Siberian is increased only by GS-HA at 10 mg/L and GN-HA at 100 mg/L. Data in **Fig. 1** (bottom) show that only D-HA at 10 mg/L and GN-HA at 100 mg/L increase the number of germinated seeds of of cv. Pryor Slender more than that of SERDP-select Siberian.
With respect to the control, the presence of any HA at any concentration increases highly significantly the primary root length of both varieties, whereas no effect is shown in any case on shoot length **(Table 9)**. Data in **Fig. 2** (bottom) indicate that, with respect to the controls, in the presence of any HA at any concentration primary root length of SERDP-select Siberian increases slightly more than that of Pryor Slender, whereas only D-HA and GS-HA at both concentrations promote primary shoot length of the former variety with respect to the other.

1.2.2. pH of the growth medium

Statistical treatment of data by one-way analysis of variance shows that, with respect to the corresponding controls, the pH of the medium is affected highly significantly during the 21-day growth period of seedlings only in COMBI-D and –F **(Tables 1-3)**. A highly significant acidification of the growth medium is measured for COMBI-D in treatments with any HA and COMBI-F in the treatment with D-HA at the higher HA concentration **(Table 10)**.

1.2.3. Early growth data

Statistical treatment of data by one-way analysis of variance shows, with respect to the corresponding controls, and as a function of either the HA type or HA concentration, the existence of: (a) a generally highly significant difference for all parameters of cv. Pryor Slender and for shoot length and root dry weight of SERDP-select Slender in **COMBI-D (Table 1)**; (b) a highly significant difference for all parameters of cv. Vavilov Siberian and for root fresh and dry weights of cv. Pryor Slender in **COMBI-E (Table 2)**; and (c) a significant or highly significant difference for all parameters of cv. Pryor Slender, except shoot length and root dry weight, and SERDP-select Siberian, except root fresh and dry weight in **COMBI-F (Table 3)**.

COMBI-D

Numerical data in **Tables 11, 14 and 17** indicate that, with respect to the control, and with few exceptions, HA treatments promote, often significantly or highly significantly, root and shoot growth of cv. Pryor Slender. Similar effects, even if less pronounced, are measured for the variety grown in combination, i.e. SERDP-select Slender, in the presence of the three HAs, especially at the higher concentration.
Data in **Figs. 3-5** (top) show that, with the exception of root dry weight in the presence of D-HA at both concentrations, any HA at any concentration increase root length and root and shoot fresh and dry weights of cv. Pryor Slender more than those of SERDP-select Slender.

COMBI-E

Numerical data in **Tables 12, 15, and 18** indicate that, with respect to the control, HA treatments have variable effects, often significant or highly significant, on the growth of the two cvs. in combination, either depressing or stimulating root and shoot elongation and fresh and dry weights. In particular: (a) root length and shoot fresh weight of cv. Vavilov Siberian are highly significantly depressed, respectively, by D-HA at 10 mg/L and GS-HA at 100 mg/L, and by D-HA at 10 mg/L, (b) a significant or higly significant favorable effect on cv. Vavilov Siberian is exerted by D-HA at 100 mg/L on shoot length, by GN-HA at 10 mg/L on root fresh weight and by D-HA at 100 mg/L and GN-HA at 10 mg/L on shoot fresh weight, by D-HA at 10 mg/L and GN-HA at both concentrations on root dry weight, and by GN-HA at 10 mg/L on shoot dry weight; (c) a significant or highly significant favorable effect is exerted by the three HAs at 10 mg/L on root fresh weight and by GS-HA and GN-HA at 10 mg/L on root dry weight of cv. Pryor Slender.
Data in **Figs. 3-5** (middle) show that, with respect to the controls, the presence of HA variously promotes the early growth of cv. Pryor Slender with respect to that of cv. Vavilov Siberian. In particular, root length is promoted by D-HA at 10 mg/L and GS-HA and GN-HA at 100 mg/L, shoot length by D-HA and GN-HA at 10 mg/L, root fresh weight by D-HA at 10 mg/L, GS-HA at both concentrations and GN-HA at 100 mg/L, shoot fresh weight only slightly by D-HA at 10 mg/L and GS-HA and GN-HA at 100 mg/L, and shoot dry weight only by GS-HA at 100 mg/L.

COMBI-F

Numerical data in **Tables 13, 16, and 19** show that, with respect to the control and with few exceptions, all HA treatments depress, often significantly or highly significantly, the growth of both varieties. In particular, D-HA at 100 mg/L reduces highly significantly or significantly root length and shoot fresh and dry weight of cv. Pryor Slender and root and shoot lengths and shoot fresh and dry weight of cv. SERDP-select Siberian, whereas only GS-HA appears to increase significantly root fresh weight of cv. Pryor Slender.
Data in **Figs. 3-5** (bottom) show that, with respect to the controls: (a) the presence of any HA at any concentration has a slightly less reducing effect on shoot length and only GS-HA at 100 mg/L on root length of cv. Pryor Slender with respect to SERDP-select Siberian; (b) only GN-HA at 100 mg/L exerts a less reducing effect on root and shoot fresh weights of SERDP-select Siberian with respect to cv. Pryor Slender; (c) GN-HA at both concentrations reduces root and shoot dry weights of SERDP-select Siberian less than those of cv. Pryor Slender by, whereas an opposite effect is exerted by D-HA and GS-HA at both concentrations on the two varieties grown in combination.

1.3. Concluding comments

Although the **germination and early growth** of the wheatgrass varieties in the three combinations examined are affected in different ways and at different extent by the HA origin and concentration, some general effects can be observed:

(a) in **COMBI-D (cv. Pryor Slender and SERDP-select Slender)**, HA treatments generally appear not to influence statistically the germination parameters of both varieties, but promote the germination of SERDP-select Slender with respect to that of cv. Pryor Slender, whereas the opposite effect is apparent for early growth;

(b) in **COMBI-E (cv. Pryor Slender and cv. Vavilov Siberian)**, HA treatments generally appear to favor germination of cv. Vavilov Siberian more than that of cv. Pryor Slender, whereas the opposite effect is apparent for early growth;

(c) in **COMBI-F (cv. Pryor Slender and SERDP-select Siberian)**, HA treatments generally appear to promote the germination % of cv. Pryor Slender more than that of SERDP-select Siberian, whereas the opposite occurs for primary root and shoot lengths. However, with few exceptions, HA treatments appear to depress the early growth of both varieties, but shoot and root lenghts of cv. Pryor Slender decrease less than that of SERDP-select Siberian, whereas the opposite effect appears generally to occur for root and shoot fresh weights of the two varieties.

(2) RESEARCH PLANS FOR THE REMAINDER OF THE CONTRACT PERIOD
NONE.PROJECT COMPLETED.

(3) SIGNIFICANT ADMINISTRATIVE ACTIONS DURING THE PERIOD REPORTED: NONE.

(4) ANY OTHER INFORMATION :
NONE.

(5) ANNEX: TABLES 1 TO 19 AND FIGURES 1 TO 5.

(A) AMOUNT OF UNUSED FUNDS REMAINING ON THE CONTRACT AT THE END OF THE PERIOD COVERED BY THE REPORT: US$ 0.

(B) IMPORTANT PROPERTIES ACQUIRED WITH CONTRACT DURING THIS PERIOD: NONE.

(C) METHOD OF REPRODUCTION: E-MAIL ATTACHMENTS, PHOTOCOPYING.

Table 1. Significance level (F value) resulting from one-way Analysis of Variance (ANOVA) of all data obtained for each parameter measured distinctly (except pH) for variety in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Parameter	**cv. Pryor Slender**	**SERDP-select Slender**
Germination	1.41 ^{ns}	0.82 ^{ns}
Primary root length	1.60 ^{ns}	3.42 *
Primary shoot length	1.18 ^{ns}	2.50 *
pH	9.28 ***	
Root length	6.61 ***	0.99 ^{ns}
Shoot length	6.10 ***	3.46 *
Root fresh weight	6.90 ***	0.52 ^{ns}
Shoot fresh weight	5.55 ***	1.65 ^{ns}
Root dry weight	2.65 *	3.94 **
Shoot dry weight	3.92 **	1.77 ^{ns}

*** 0.001; ** 0.01 P; * 0.05 P; ns: nonsignificant

Table 2. Significance level (F value) resulting from one-way Analysis of Variance (ANOVA) of all data obtained for each parameter measured distinctly (except pH) for variety in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Parameter	**cv. Pryor Slender**	**cv. Vavilov Siberian**
Germination	1.66 ^{ns}	2.51 *
Primary root length	2.77 *	3.69 **
Primary shoot length	1.37 ^{ns}	3.70 **
pH	1.93 ^{ns}	
Root length	1.49 ^{ns}	5.14 **
Shoot length	2.45 ^{ns}	5.18 **
Root fresh weight	3.56 **	13.35 ***
Shoot fresh weight	0.78 ^{ns}	9.31 ***
Root dry weight	5.84 ***	6.89 ***
Shoot dry weight	1.41 ^{ns}	6.61 ***

*** 0.001; ** 0.01 P; * 0.05 P; ns: nonsignificant

Table 3. Significance level (F value) resulting from one-way Analysis of Variance (ANOVA) of all data obtained for each parameter measured distinctly (except pH) for variety in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Parameter	**cv. Pryor Slender**	**SERDP-select Siberian**
Germination	2.67 *	6.54 **
Primary root length	4.07 **	4.59 **
Primary shoot length	0.93 ^{ns}	1.10 ^{ns}
pH	4.35 **	
Root length	3.90 **	2.87 *
Shoot length	1.91 ^{ns}	2.71 *
Root fresh weight	2.51 *	0.98 ^{ns}
Shoot fresh weight	3.80 **	3.35 **
Root dry weight	0.86 ^{ns}	2.30 ^{ns}
Shoot dry weight	3.27 *	3.09 *

** 0.01 P; * 0.05 P; ns: nonsignificant

Table 4. Effect of HAs at different concentrations on seed germination (expressed as % of germinated seeds) in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Treatment	**cv. Pryor Slender**		**SERDP-select Slender**	
	(absolute %)	(% of control)	(absolute %)	(% of control)
Control (H_2O)	58 ± 1.8[a]	100.0 ± 3.1[a]	56 ± 8.3	100.0 ± 14.8
D HA				
10 mg/L	50 ± 2.8	86.2 ± 4.9	60 ± 4.0	107.1 ± 7.1
100 mg/L	46 ± 7.3	79.3 ± 12.5	56 ± 7.3	100.0 ± 13.0
GS HA				
10 mg/L	40 ± 2.8	69.0 ± 4.9	44 ± 4.6	78.6 ± 8.1
100 mg/L	52 ± 3.4	89.7 ± 5.8	60 ± 9.4	107.1 ± 16.8
GN HA				
10 mg/L	46 ± 2.2	79.3 ± 3.8	50 ± 4.9	89.3 ± 8.7
100 mg/L	52 ± 6.6	89.7 ± 11.3	46 ± 4.6	82.1 ± 8.1

[a] standard error (n=5)

Table 5. Effect of HAs at different concentrations on seed germination (expressed as % of germinated seeds) in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Treatment	**cv. Pryor Slender**		**cv. Vavilov Siberian**		
	(absolute %)	(% of control)	(absolute %)	(% of control)	
Control (H_2O)	40 ± 5.7[a]	100.0 ± 14.1[a]	50 ± 5.7	100.0 ± 11.3	
D HA					
10 mg/L	46 ± 4.6	115.0 ± 11.4	54 ± 4.6	108.0 ± 9.1	
100 mg/L	42 ± 6.6	105.0 ± 16.4	50 ± 4.0	100.0 ± 8.0	
GS HA					
10 mg/L	52 ± 3.4	130.0 ± 8.4	70 ± 0.0	140.0 ± 0.0	*
100 mg/L	30 ± 0.0	75.0 ± 0.0	66 ± 4.6	132.0 ± 9.1	*
GN HA					
10 mg/L	48 ± 6.6	120.0 ± 16.4	62 ± 4.4	124.0 ± 8.8	
100 mg/L	48 ± 5.2	120.0 ± 13.0	58 ± 5.2	116.0 ± 10.4	

[a] standard error (n=5)
* $P \leq 0.05$, according to the LSD test.

Table 6. Effect of HAs at different concentrations on seed germination (expressed as % of germinated seeds) in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Treatment	**cv. Pryor Slender**			**SERDP-select Siberian**		
	(absolute %)	(% of control)		(absolute %)	(% of control)	
Control (H_2O)	48 ± 1.8[a]	100.0 ± 3.7[a]		50 ± 4.0	100.0 ± 8.0	
D HA						
10 mg/L	64 ± 4.6	133.3 ± 9.5	*	40 ± 2.8	80.0 ± 5.7	
100 mg/L	58 ± 4.4	120.8 ± 9.1		60 ± 2.8	120.0 ± 5.7	
GS HA						
10 mg/L	62 ± 5.2	129.2 ± 10.9	*	62 ± 4.4	124.0 ± 8.8	*
100 mg/L	46 ± 4.6	95.8 ± 9.5		42 ± 3.4	84.0 ± 6.7	
GN HA						
10 mg/L	54 ± 3.6	112.5 ± 7.5		64 ± 4.6	128.0 ± 9.1	*
100 mg/L	64 ± 3.6	133.3 ± 7.5	*	40 ± 4.0	80.0 ± 8.0	

[a] standard error (n=5)
** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 7. Effect of HAs at different concentrations on the length of primary root and shoot of germinated seeds in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Treatment	cv. Pryor Slender				SERDP-select Slender				
	Root		Shoot		Root			Shoot	
	(cm)	(%)	(cm)	(%)	(cm)	(%)		(cm)	(%)
Control (H_2O)	1.8 ± 0.2[a]	100.0 ± 12.3[a]	2.2 ± 0.2	100.0 ± 7.1	1.8 ± 0.1	100.0 ± 5.9		2.3 ± 0.1	100.0 ± 5.8
D HA									
10 mg/L	2.2 ± 0.2	118.4 ± 9.4	2.1 ± 0.1	94.8 ± 5.7	2.3 ± 0.1	129.8 ± 6.4	*	2.5 ± 0.1	110.7 ± 4.2
100 mg/L	2.4 ± 0.2	130.2 ± 8.3	2.4 ± 0.3	108.7 ± 15.3	2.3 ± 0.1	129.1 ± 5.9	*	2.5 ± 0.3	107.5 ± 11.2
GS HA									
10 mg/L	2.3 ± 0.2	124.9 ± 8.6	1.8 ± 0.2	82.0 ± 7.5	2.1 ± 0.2	119.1 ± 9.5		1.8 ± 0.1	80.1 ± 3.2
100 mg/L	2.3 ± 0.2	127.3 ± 8.8	2.2 ± 0.1	101.9 ± 4.9	2.5 ± 0.1	140.0 ± 7.7	*	2.9 ± 0.2	126.4 ± 9.9 *
GN HA									
10 mg/L	1.8 ± 0.1	96.6 ± 7.4	1.9 ± 0.1	87.4 ± 3.2	1.9 ± 0.2	105.3 ± 8.9		2.2 ± 0.2	94.4 ± 8.4
100 mg/L	2.2 ± 0.2	120.8 ± 10.4	2.4 ± 0.3	112.2 ± 12.6	1.9 ± 0.1	108.3 ± 4.7		2.3 ± 0.2	102.5 ± 10.2

[a] standard error (n=5)

* $P \leq 0.05$, according to the LSD test.

Table 8. Effect of HAs at different concentrations on the length of primary root and shoot of germinated seeds in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Treatment	cv. Pryor Slender				cv. Vavilov Siberian			
	Root		Shoot		Root		Shoot	
	(cm)	(%)	(cm)	(%)	(cm)	(%)	(cm)	(%)
Control (H_2O)	1.7 ± 0.2[a]	100.0 ± 9.4[a]	1.3 ± 0.1	100.0 ± 9.8	1.7 ± 0.1	100.0 ± 8.1	2.1 ± 0.2	100.0 ± 7.7
D HA								
10 mg/L	2.3 ± 0.0	136.9 ± 2.3 *	1.4 ± 0.1	107.7 ± 7.7	2.7 ± 0.2	160.1 ± 9.7 **	2.6 ± 0.2	122.5 ± 7.7
100 mg/L	1.7 ± 0.1	105.3 ± 8.7	1.3 ± 0.1	97.1 ± 10.6	2.4 ± 0.2	147.2 ± 13.7 *	2.7 ± 0.1	125.0 ± 4.5 *
GS HA								
10 mg/L	2.1 ± 0.1	124.5 ± 6.7 *	1.6 ± 0.2	119.3 ± 12.0	3.0 ± 0.2	183.3 ± 14.7 **	3.2 ± 0.3	148.5 ± 13.1 **
100 mg/L	1.9 ± 0.2	112.8 ± 9.0	1.6 ± 0.2	121.1 ± 11.7	2.5 ± 0.2	153.3 ± 11.6 **	2.5 ± 0.1	115.8 ± 4.7
GN HA								
10 mg/L	1.9 ± 0.1	112.2 ± 3.7	1.4 ± 0.1	104.9 ± 10.6	2.3 ± 0.2	139.7 ± 11.1 *	2.2 ± 0.2	104.2 ± 7.0
100 mg/L	2.2 ± 0.2	132.9 ± 9.1 *	1.8 ± 0.1	134.9 ± 9.1	2.6 ± 0.2	158.9 ± 12.9 **	2.3 ± 0.1	106.8 ± 5.7

[a] standard error (n=5)
** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 9. Effect of HAs at different concentrations on the length of primary root and shoot of germinated seeds in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Treatment	cv. Pryor Slender					SERDP-select Siberian				
	Root			Shoot		Root			Shoot	
	(cm)	(%)		(cm)	(%)	(cm)	(%)		(cm)	(%)
Control (H_2O)	1.3 ± 0.1[a]	100.0 ± 5.9		1.0 ± 0.1	100.0 ± 12.3	1.2 ± 0.2[a]	100.0 ± 12.4		1.7 ± 0.1	100.0 ± 7.8
D HA										
10 mg/L	2.1 ± 0.1	164.3 ± 6.2	**	0.9 ± 0.1	91.3 ± 5.5	2.4 ± 0.1	191.0 ± 6.1	***	2.0 ± 0.2	120.0 ± 9.1
100 mg/L	2.0 ± 0.2	155.3 ± 12.7	**	1.0 ± 0.1	104.4 ± 9.0	2.1 ± 0.2	171.1 ± 14.5	***	1.8 ± 0.2	111.2 ± 14.4
GS HA										
10 mg/L	2.1 ± 0.1	163.8 ± 7.7	**	1.0 ± 0.0	95.7 ± 4.4	2.5 ± 0.1	200.6 ± 6.2	***	2.0 ± 0.1	118.0 ± 7.6
100 mg/L	1.9 ± 0.2	150.7 ± 13.6	**	1.1 ± 0.1	109.8 ± 9.3	2.2 ± 0.2	180.8 ± 15.4	***	2.1 ± 0.2	124.3 ± 13.4
GN HA										
10 mg/L	2.0 ± 0.1	152.5 ± 6.2	**	1.1 ± 0.1	108.6 ± 9.1	2.1 ± 0.1	170.5 ± 9.1	***	1.8 ± 0.2	105.3 ± 9.7
100 mg/L	2.1 ± 0.2	164.4 ± 14.3	**	1.2 ± 0.1	120.1 ± 10.4	2.1 ± 0.2	167.8 ± 15.0	***	1.5 ± 0.1	90.7 ± 7.3

[a] standard error (n=5)

*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 10. Effect of HAs at different concentrations on the pH value of growth medium measured after 21-day seedling growth in the three combinations.

Treatment	**cv. Pryor Slender and SERDP-select Slender**	**cv. Pryor Slender and cv. Vavilov Siberian**	**cv. Pryor Slender and SERDP-select Siberian**
Control (H_2O)	6.1 ± 0.1[a]	6.3 ± 0.0	4.0 ± 0.3
D HA			
10 mg/L	5.9 ± 0.2	6.4 ± 0.1	3.7 ± 0.1
100 mg/L	5.1 ± 0.4**	6.2 ± 0.0	4.8 ± 0.2 **
GS HA			
10 mg/L	5.9 ± 0.1	6.2 ± 0.1	4.1 ± 0.2
100 mg/L	4.4 ± 0.3***	5.7 ± 0.4	3.8 ± 0.1
GN HA			
10 mg/L	5.9 ± 0.2	5.8 ± 0.1	3.8 ± 0.1
100 mg/L	4.5 ± 0.1***	5.5 ± 0.4	3.7 ± 0.1

[a] standard error (n=5)
*** $P \leq 0.001$; ** $P \leq 0.01$, according to the LSD test.

Table 11. Effect of HAs at different concentrations on the length of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Treatment	cv. Pryor Slender						SERDP-select Slender					
	Root			Shoot			Root			Shoot		
	(cm)	(%)		(cm)	(%)		(cm)	(%)		(cm)	(%)	
Control (H_2O)	13.2 ± 1.9[a]	100.0 ± 22.4[a]		4.1 ± 0.3	100.0 ± 10.2		16.8 ± 1.0	100.0 ± 9.6		3.9 ± 0.2	100.0 ± 9.6	
D HA												
10 mg/L	24.5 ± 1.9	185.3 ± 14.4	***	4.6 ± 0.2	110.3 ± 5.5		21.3 ± 1.0	126.9 ± 5.8		4.4 ± 0.2	110.8 ± 5.8	
100 mg/L	22.0 ± 1.1	166.8 ± 8.2	***	5.4 ± 0.3	131.7 ± 6.7	**	15.6 ± 2.7	92.7 ± 16.2		4.7 ± 0.1	119.3 ± 3.7	*
GS HA												
10 mg/L	18.5 ± 0.9	139.9 ± 6.7	*	3.9 ± 0.3	95.3 ± 7.8		15.5 ± 3.0	92.4 ± 17.7		3.7 ± 0.2	93.9 ± 6.2	
100 mg/L	23.2 ± 1.5	176.0 ± 11.2	***	5.4 ± 0.3	131.3 ± 7.9	**	17.0 ± 1.0	101.4 ± 5.9		4.6 ± 0.2	116.8 ± 3.9	*
GN HA												
10 mg/L	24.0 ± 1.4	182.0 ± 10.4	***	5.5 ± 0.2	132.5 ± 3.7	**	18.5 ± 0.7	109.9 ± 4.3		4.0 ± 0.1	102.4 ± 3.7	
100 mg/L	19.0 ± 0.8	144.0 ± 6.0	*	5.7 ± 0.2	137.3 ± 5.0	***	18.7 ± 2.0	115.5 ± 12.0		4.9 ± 0.3	123.1 ± 6.6	*

[a] standard error (n=5)

*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 12. Effect of HAs at different concentrations on the length of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Treatment	cv. Pryor Slender				cv. Vavilov Siberian				
	Root		Shoot		Root			Shoot	
	(cm)	(%)	(cm)	(%)	(cm)	(%)		(cm)	(%)
Control (H_2O)	17.9 ± 1.0[a]	100.0 ± 8.9[a]	5.1 ± 0.2	100.0 ± 6.1	15.4 ± 0.8	100.0 ± 8.2		4.1 ± 0.2	100.0 ± 7.0
D HA									
10 mg/L	15.9 ± 2.0	89.1 ± 10.9	5.2 ± 0.2	101.0 ± 3.4	9.8 ± 0.9	63.6 ± 6.0	**	3.6 ± 0.2	85.9 ± 3.6
100 mg/L	17.7 ± 1.1	98.7 ± 6.1	5.1 ± 0.3	98.4 ± 6.5	15.5 ± 0.6	100.6 ± 3.6		5.0 ± 0.1	121.0 ± 1.6 **
GS HA									
10 mg/L	15.6 ± 1.6	87.0 ± 8.7	4.4 ± 0.2	84.8 ± 3.4	13.3 ± 1.2	86.3 ± 8.1		4.2 ± 0.2	101.6 ± 5.3
100 mg/L	14.9 ± 2.6	83.5 ± 14.3	5.4 ± 0.1	105.2 ± 2.6	9.4 ± 0.9	60.8 ± 5.6	**	4.7 ± 0.3	112.5 ± 6.1
GN HA									
10 mg/L	17.0 ± 0.4	94.8 ± 2.3	5.7 ± 0.3	110.8 ± 6.5	16.7 ± 1.4	108.4 ± 8.8		4.4 ± 0.1	106.9 ± 3.1
100 mg/L	22.1 ± 2.5	123.6 ± 14.1	5.4 ± 0.2	105.2 ± 4.2	12.3 ± 1.7	80.0 ± 11.3		4.6 ± 0.2	111.7 ± 5.3

[a] standard error (n=5)
** $P \leq 0.01$, according to the LSD test.

Table 13. Effect of HAs at different concentrations on the length of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Treatment	cv. Pryor Slender				SERDP-select Siberian			
	Root		Shoot		Root		Shoot	
	(cm)	(%)	(cm)	(%)	(cm)	(%)	(cm)	(%)
Control (H_2O)	22.6 ± 1.6[a]	100.0 ± 11.0[a]	6.2 ± 0.2	100.0 ± 4.4	17.3 ± 0.4	100.0 ± 3.5	6.2 ± 0.3	100.0 ± 7.2
D HA								
10 mg/L	21.9 ± 1.7	97.0 ± 7.6	6.1 ± 0.3	98.4 ± 4.2	17.0 ± 1.3	98.1 ± 7.4	5.6 ± 0.2	90.9 ± 2.8
100 mg/L	13.3 ± 1.9	58.9 ± 8.3 **	4.7 ± 0.4	76.2 ± 6.9	12.6 ± 1.5	72.7 ± 8.4 *	4.2 ± 0.6	68.3 ± 10.2 *
GS HA								
10 mg/L	22.2 ± 1.7	98.2 ± 7.6	6.2 ± 0.6	100.0 ± 9.1	17.5 ± 0.3	101.2 ± 1.9	6.0 ± 0.4	96.2 ± 7.2
100 mg/L	21.9 ± 1.8	97.0 ± 8.0	6.0 ± 0.2	97.3 ± 2.5	14.6 ± 1.4	84.2 ± 7.8	5.7 ± 0.2	91.4 ± 3.1
GN HA								
10 mg/L	21.5 ± 0.6	95.0 ± 2.7	5.9 ± 0.3	95.9 ± 5.1	16.8 ± 0.9	97.1 ± 4.9	5.5 ± 0.1	89.2 ± 2.3
100 mg/L	18.1 ± 1.1	80.0 ± 4.7	6.0 ± 0.3	97.3 ± 4.5	14.3 ± 0.7	82.7 ± 4.0	6.2 ± 0.4	10.0 ± 6.8

[a] standard error (n=5)

* $P \leq 0.05$, according to the LSD test.

Table 14. Effect of HAs at different concentrations on the fresh weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Treatment	cv. Pryor Slender						SERDP-select Slender					
	Root			Shoot			Root			Shoot		
	(mg)	(%)		(mg)	(%)		(mg)	(%)		(mg)	(%)	
Control (H_2O)	17.2 ± 4.0[a]	100.0 ± 23.1[a]		31.1 ± 9.2	100.0 ± 29.6		17.5 ± 4.2	100.0 ± 24.2		33.6 ± 5.8	100.0 ± 17.4	
D HA												
10 mg/L	44.1 ± 3.6	25.6.9 ± 21.1	***	59.5 ± 7.1	191.3 ± 22.8	*	25.6 ± 2.5	146.7 ± 14.4		38.6 ± 2.9	114.9 ± 8.7	
100 mg/L	22.0 ± 3.9	128.3 ± 22.7		78.7 ± 11.9	253.0 ± 38.2	***	22.2 ± 3.7	126.9 ± 21.4		49.8 ± 10.8	148.2 ± 32.0	
GS HA												
10 mg/L	31.0 ± 6.9	181.0 ± 40.4	*	32.1 ± 5.9	103.2 ± 18.8		19.1 ± 7.3	109.6 ± 41.8		30.5 ± 6.9	90.9 ± 20.5	
100 mg/L	51.6 ± 5.3	300.8 ± 30.9	***	77.0 ± 7.1	247.8 ± 22.8	***	20.6 ± 3.6	118.0 ± 20.9		46.4 ± 3.2	138.2 ± 9.4	
GN HA												
10 mg/L	47.3 ± 3.6	275.6 ± 20.7	***	64.6 ± 6.1	207.7 ± 19.6	**	16.1 ± 1.3	92.0 ± 7.4		25.9 ± 1.5	77.1 ± 4.6	
100 mg/L	36.4 ± 2.0	212.0 ± 11.7	**	72.8 ± 3.5	234.1 ± 11.2	**	22.9 ± 3.5	131.4 ± 19.8		43.4 ± 6.5	129.1 ± 19.2	

[a] standard error (n=5)

*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 15. Effect of HAs at different concentrations on the fresh weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Treatment	cv. Pryor Slender				cv. Vavilov Siberian			
	Root		Shoot		Root		Shoot	
	(mg)	(%)	(mg)	(%)	(mg)	(%)	(mg)	(%)
Control (H_2O)	23.1 ± 2.0[a]	100.0 ± 8.6[a]	75.3 ± 6.8	100.0 ± 9.0	20.4 ± 1.8	100.0 ± 8.9	47.7 ± 1.9	100.0 ± 4.0
D HA								
10 mg/L	39.5 ± 3.2	170.6 ± 14.0 *	47.4 ± 4.6	63.0 ± 6.1	26.5 ± 2.9	130.0 ± 14.0	23.3 ± 4.1	48.9 ± 8.5 **
100 mg/L	26.2 ± 3.0	113.3 ± 13.1	69.4 ± 10.3	92.2 ± 13.7	27.9 ± 1.6	133.8 ± 7.7	67.1 ± 1.9	140.6 ± 4.0 *
GS HA								
10 mg/L	40.0 ± 6.7	173.0 ± 28.8 *	50.6 ± 7.2	67.2 ± 9.5	25.5 ± 3.4	125.1 ± 16.8	32.3 ± 1.8	67.8 ± 3.9
100 mg/L	32.2 ± 3.3	138.9 ± 14.4	62.6 ± 14.0	83.1 ± 13.9	19.5 ± 1.6	95.3 ± 7.7	34.6 ± 10.1	72.5 ± 21.1
GN HA								
10 mg/L	49.1 ± 5.6	212.2 ± 24.4 **	88.2 ± 5.5	117.1 ± 7.3	47.7 ± 6.7	233.7 ± 12.7 ***	73.7 ± 12.4	154.5 ± 14.4 **
100 mg/L	34.5 ± 3.5	149.0 ± 15.1	67.7 ± 9.9	89.9 ± 18.2	22.9 ± 1.9	112.3 ± 9.1	37.7 ± 6.0	79.1 ± 12.6

[a] standard error (n=5)

*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 16. Effect of HAs at different concentrations on the fresh weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Treatment	cv. Pryor Slender					SERDP-select Siberian				
	Root		Shoot			Root		Shoot		
	(mg)	(%)	(mg)	(%)		(mg)	(%)	(mg)	(%)	
Control (H_2O)	29.1 ± 5.2[a]	100.0 ± 17.9[a]	119.5 ± 9.1	100.0 ± 7.6		50.2 ± 8.9	100.0 ± 17.8	157.0 ± 28.5	100.0 ± 18.2	
D HA										
10 mg/L	31.6 ± 2.4	108.5 ± 8.1	132.7 ± 14.8	111.1 ± 12.4		38.2 ± 2.8	75.1 ± 5.5	132.2 ± 9.4	84.3 ± 6.0	
100 mg/L	30.4 ± 3.2	104.5 ± 10.9	60.1 ± 11.7	50.3 ± 9.8	**	31.0 ± 7.5	61.8 ± 14.9	69.8 ± 21.5	44.5 ± 13.7	**
GS HA										
10 mg/L	45.2 ± 7.0	155.2 ± 23.9	*	115.9 ± 15.2	97.0 ± 12.7		49.6 ± 9.9	98.9 ± 19.7	137.7 ± 16.0	87.7 ± 10.2
100 mg/L	29.5 ± 0.6	97.8 ± 2.0	109.5 ± 7.4	91.7 ± 6.2		32.6 ± 5.6	64.9 ± 11.1	114.4 ± 8.4	72.9 ± 5.3	
GN HA										
10 mg/L	27.4 ± 3.3	94.1 ± 11.3	126.3 ± 6.5	105.7 ± 5.4		45.2 ± 9.6	90.1 ± 19.0	173.1 ± 14.8	110.3 ± 9.4	
100 mg/L	22.7 ± 2.7	77.9 ± 9.1	107.0 ± 8.4	89.6 ± 7.1		50.6 ± 7.1	100.8 ± 14.1	163.8 ± 12.8	104.3 ± 8.1	

[a] standard error (n=5)

** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 17. Effect of HAs at different concentrations on the dry weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Slender (COMBI-D)**.

Treatment	cv. Pryor Slender					SERDP-select Slender				
	Root		Shoot			Root			Shoot	
	(mg)	(%)	(mg)	(%)		(mg)	(%)		(mg)	(%)
Control (H_2O)	2.0 ± 0.6[a]	100.0 ± 6.7[a]	6.4 ± 1.1	100.0 ± 16.6		1.9 ± 0.2	100.0 ± 10.1		6.2 ± 1.0	100.0 ± 15.6
D HA										
10 mg/L	2.5 ± 0.4	127.2 ± 18.3	10.4 ± 1.2	161.0 ± 18.3	*	3.6 ± 1.3	185.5 ± 13.0	**	7.7 ± 0.6	122.9 ± 9.5
100 mg/L	2.3 ± 0.2	118.8 ± 11.9	13.0 ± 2.1	202.0 ± 32.0	**	3.3 ± 0.8	170.9 ± 9.7	**	9.5 ± 1.7	152.7 ± 27.0
GS HA										
10 mg/L	2.5 ± 0.2	130.2 ± 12.5	6.4 ± 0.8	98.6 ± 12.7		2.1 ± 0.3	107.9 ± 16.0		5.7 ± 1.1	90.6 ± 17.8
100 mg/L	3.3 ± 0.4	169.7 ± 12.3 *	12.5 ± 1.2	193.6 ± 18.4	**	2.3 ± 0.4	116.3 ± 21.4		8.5 ± 0.5	135.5 ± 7.5
GN HA										
10 mg/L	3.2 ± 0.4	161.7 ± 18.7 *	10.0 ± 1.1	155.7 ± 16.9		1.8 ± 0.1	92.6 ± 6.6	*	5.6 ± 0.3	89.3 ± 4.5
100 mg/L	2.9 ± 0.2	146.4 ± 9.6 *	11.7 ± 0.7	181.1 ± 10.5	**	2.8 ± 0.5	144.8 ± 27.6		7.8 ± 1.2	124.3 ± 19.2

[a] standard error (n=5)

** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 18. Effect of HAs at different concentrations on the dry weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and cv. Vavilov Siberian (COMBI-E)**.

Treatment	cv. Pryor Slender				cv. Vavilov Siberian				
	Root		Shoot		Root			Shoot	
	(mg)	(%)	(mg)	(%)	(mg)	(%)		(mg)	(%)
Control (H_2O)	2.9 ± 0.4[a]	100.0 ± 12.3[a]	13.4 ± 1.1	100.0 ± 8.0	1.7 ± 0.1	100.0 ± 4.3		7.1 ± 0.4	100.0 ± 5.4
D HA									
10 mg/L	3.4 ± 0.2	116.2 ± 5.0	8.8 ± 0.6	65.5 ± 4.7	2.6 ± 0.2	151.3 ± 12.2	**	4.7 ± 0.5	66.3 ± 7.0
100 mg/L	2.6 ± 0.2	87.3 ± 7.4	12.0 ± 1.8	89.5 ± 13.1	2.1 ± 0.1	121.2 ± 5.1		9.6 ± 0.4	134.4 ± 5.0
GS HA									
10 mg/L	4.1 ± 0.7	138.4 ± 6.2	*	8.6 ± 1.2	67.3 ± 17.6	2.3 ± 0.2	133.3 ± 13.0		5.3 ± 0.5	74.5 ± 6.4
100 mg/L	3.0 ± 0.2	101.8 ± 6.3	11.0 ± 2.5	81.8 ± 18.3	2.1 ± 0.1	122.4 ± 6.7		4.8 ± 1.7	67.4 ± 23.2
GN HA									
10 mg/L	4.9 ± 0.5	165.2 ± 16.9	***	14.6 ± 0.9	108.5 ± 6.3	3.5 ± 0.3	204.3 ± 16.2	***	10.9 ± 1.8	152.2 ± 9.7	**
100 mg/L	3.0 ± 0.3	100.1 ± 10.8	11.1 ± 1.6	82.9 ± 12.1	2.3 ± 0.3	135.7 ± 14.8	*	6.1 ± 1.0	85.1 ± 14.1	

[a] standard error (n=5)

*** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$, according to the LSD test.

Table 19. Effect of HAs at different concentrations on the dry weight of shoots and roots measured after 21-day growth in the combination **cv. Pryor Slender and SERDP-select Siberian (COMBI-F)**.

Treatment	cv. Pryor Slender					SERDP-select Siberian				
	Root		Shoot			Root		Shoot		
	(mg)	(%)	(mg)	(%)		(mg)	(%)	(mg)	(%)	
Control (H_2O)	3.9 ± 0.9[a]	100.0 ± 22.6[a]	20.4 ± 1.7	100.0 ± 8.3		4.3 ± 0.4	100.0 ± 10.0	21.7 ± 3.5	100.0 ± 16.0	
D HA										
10 mg/L	3.2 ± 0.4	82.1 ± 8.9	22.3 ± 2.4	109.1 ± 11.6		3.1 ± 0.2	71.5 ± 4.7	18.3 ± 1.6	84.4 ± 7.1	
100 mg/L	2.8 ± 0.3	71.8 ± 7.3	11.0 ± 1.8	54.0 ± 8.8	*	2.4 ± 0.4	56.8 ± 8.9	10.2 ± 2.5	47.1 ± 11.7	*
GS HA										
10 mg/L	3.8 ± 0.6	97.2 ± 15.4	18.8 ± 2.6	92.0 ± 12.5		3.2 ± 0.5	74.2 ± 11.6	18.7 ± 2.0	86.2 ± 9.1	
100 mg/L	3.1 ± 0.0	79.8 ± 0.7	18.4 ± 1.1	90.1 ± 5.5		2.7 ± 0.2	62.8 ± 4.8	15.1 ± 0.7	69.8 ± 3.3	
GN HA										
10 mg/L	2.9 ± 0.3	74.1 ± 8.1	22.9 ± 2.1	112.2 ± 10.1		3.8 ± 0.5	89.2 ± 12.2	30.3 ± 6.7	139.4 ± 30.8	
100 mg/L	2.7 ± 0.2	69.1 ± 3.9	19.9 ± 1.7	97.3 ± 8.2		3.3 ± 0.2	76.5 ± 5.3	22.2 ± 1.6	102.3 ± 7.6	

[a] standard error (n=5)

* $P \leq 0.05$, according to the LSD test.

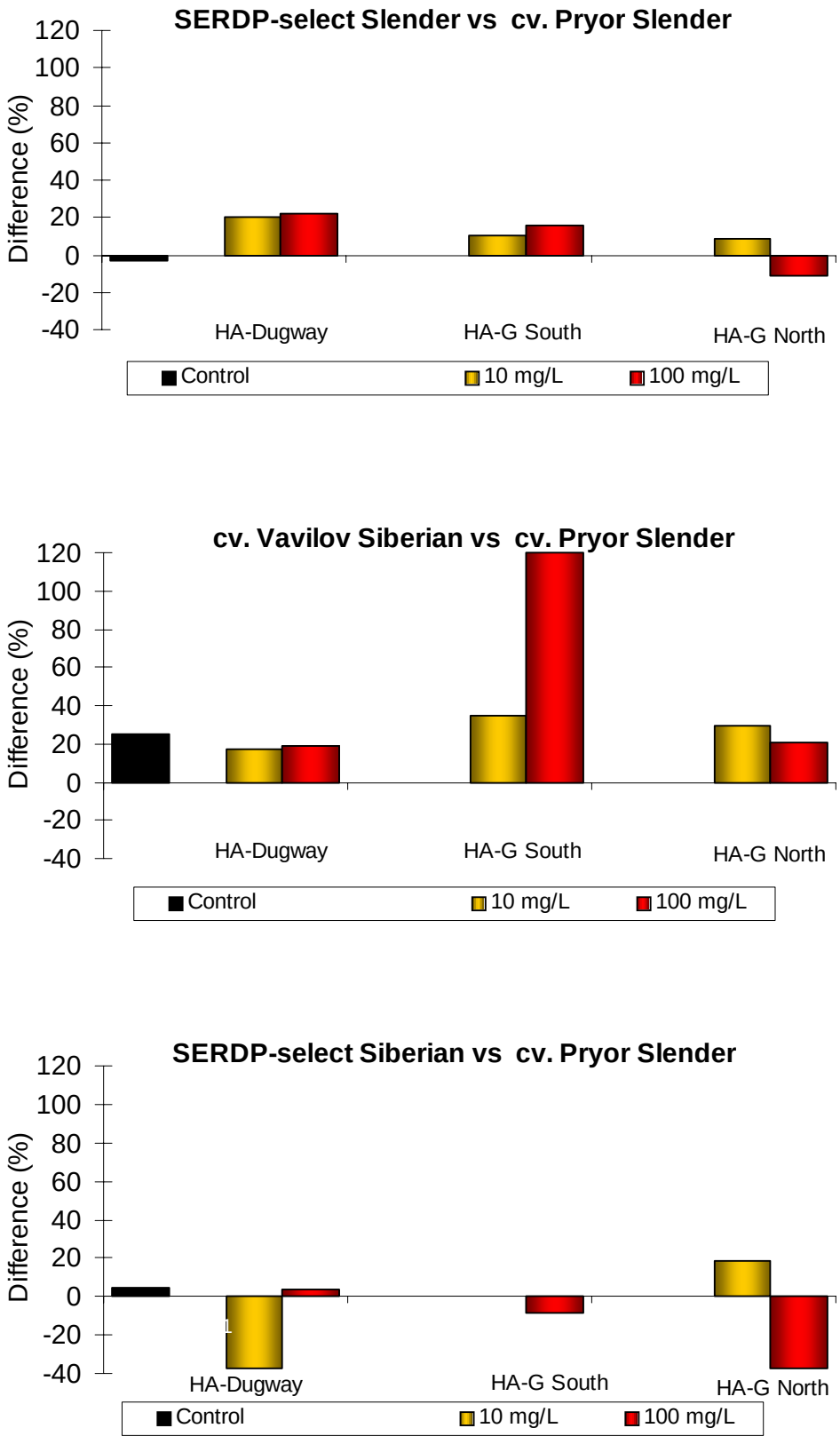
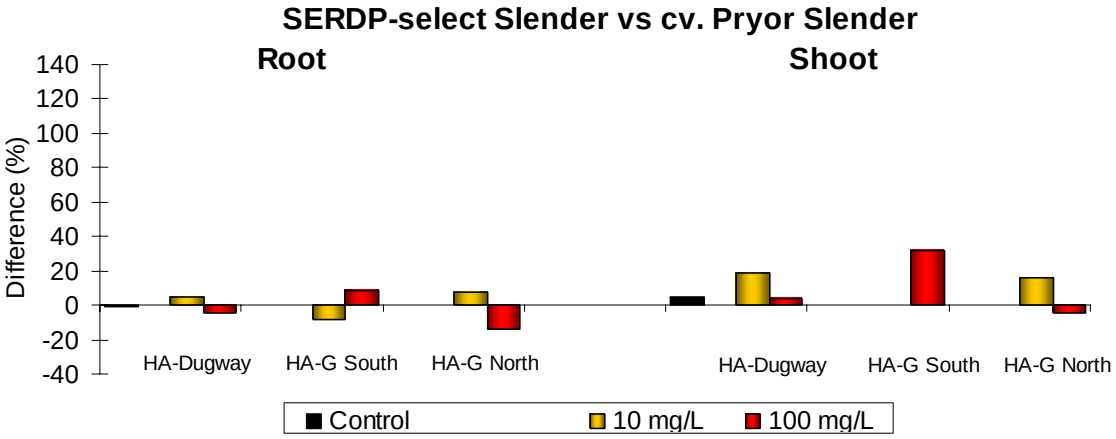
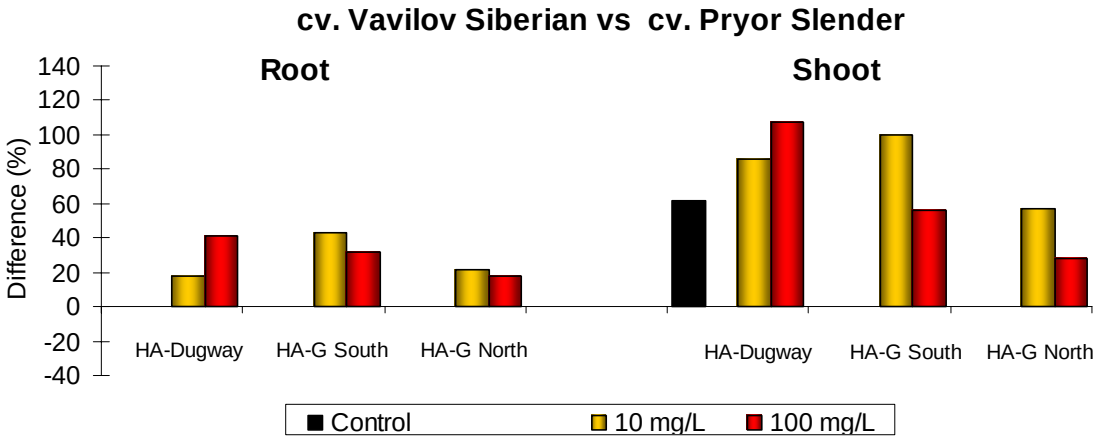


Figure 1. Effect of HAs at different concentrations on the difference (%) of number of germinated seeds between the two varieties grown together. Top, COMBI-D, middle, COMBI-E, bottom, COMBI-F.





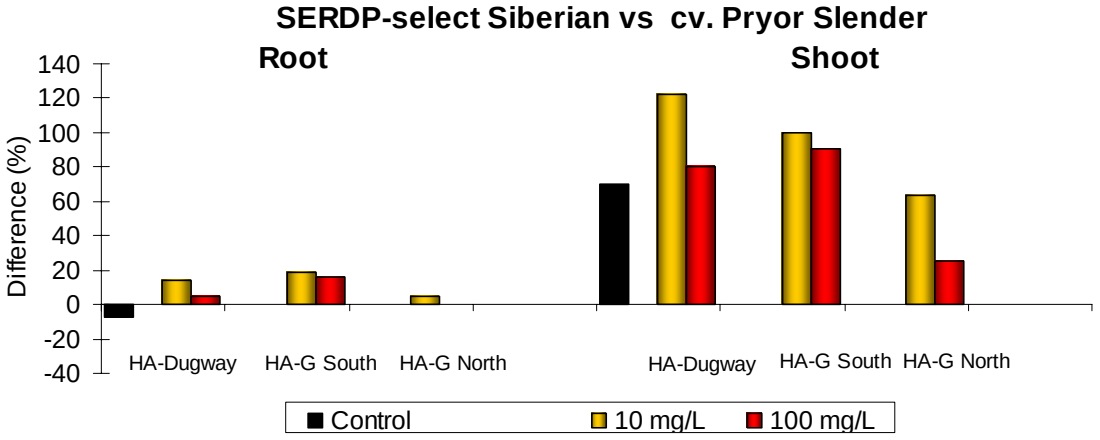
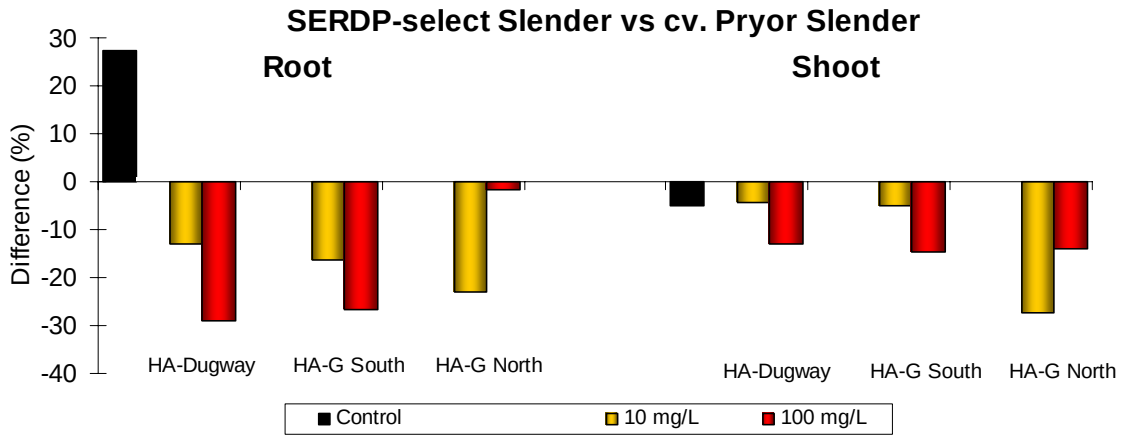
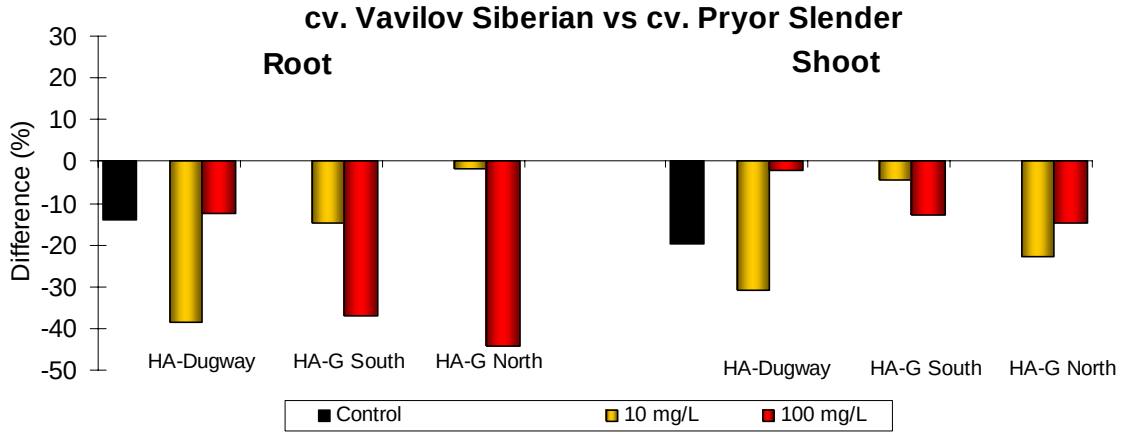


Figure 2. Effect of HAs at different concentrations on the difference (%) of primary shoot and root length of germinated seeds between the two varieties grown together. Top, COMBI-D, middle, COMBI-E, bottom, COMBI-F.





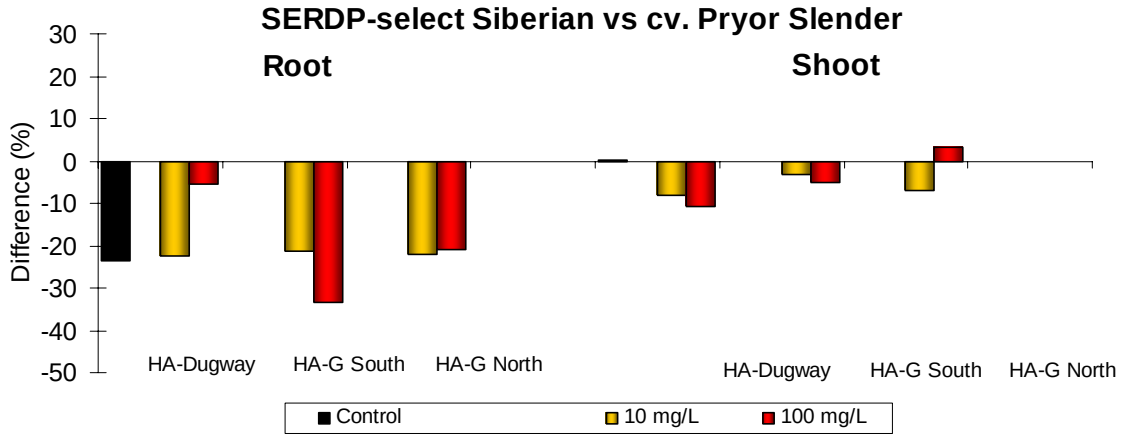
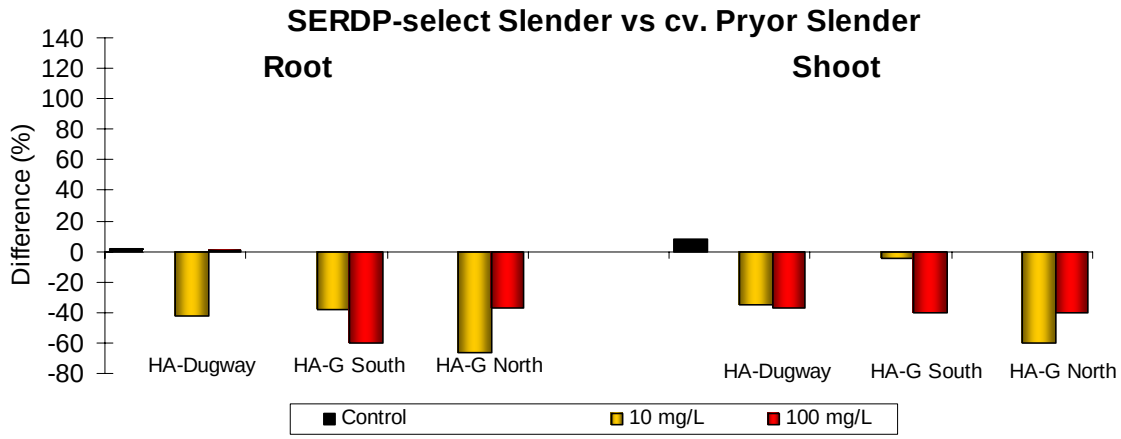
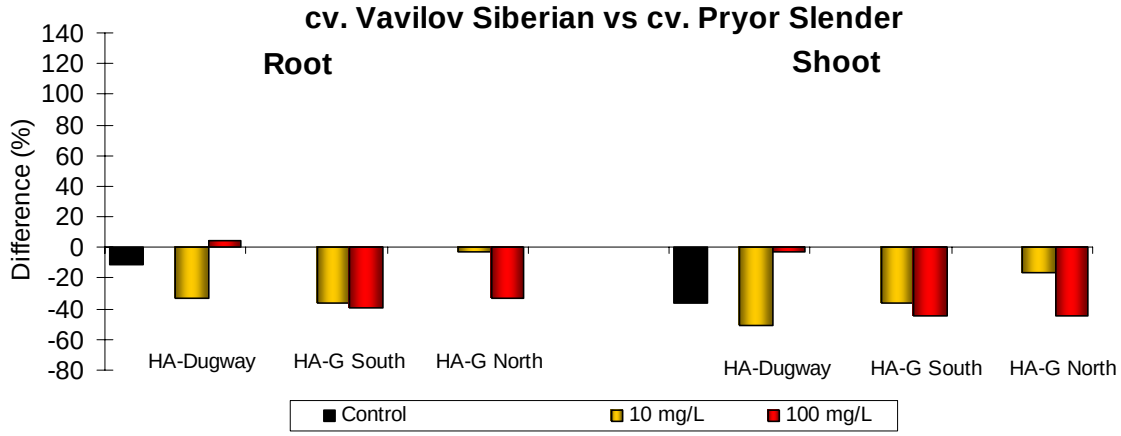


Figure 3. Effect of HAs at different concentrations on the difference (%) of shoot and root lengths between the two varieties grown together for 21-days. Top, COMBI-D, middle, COMBI-E, bottom, COMBI-F.





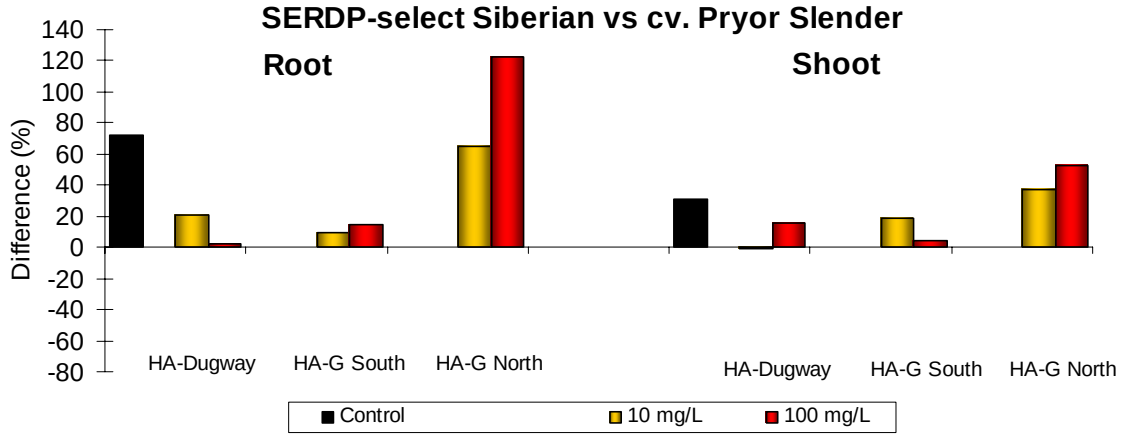
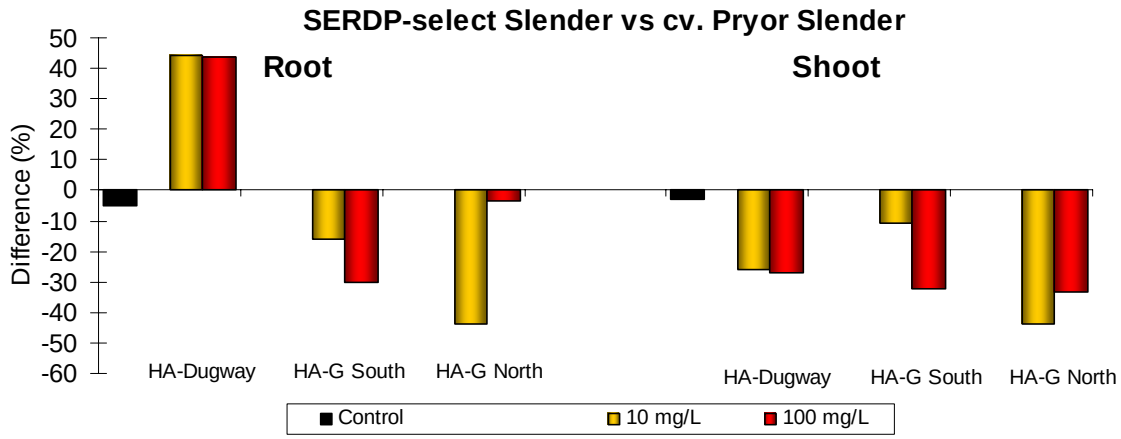
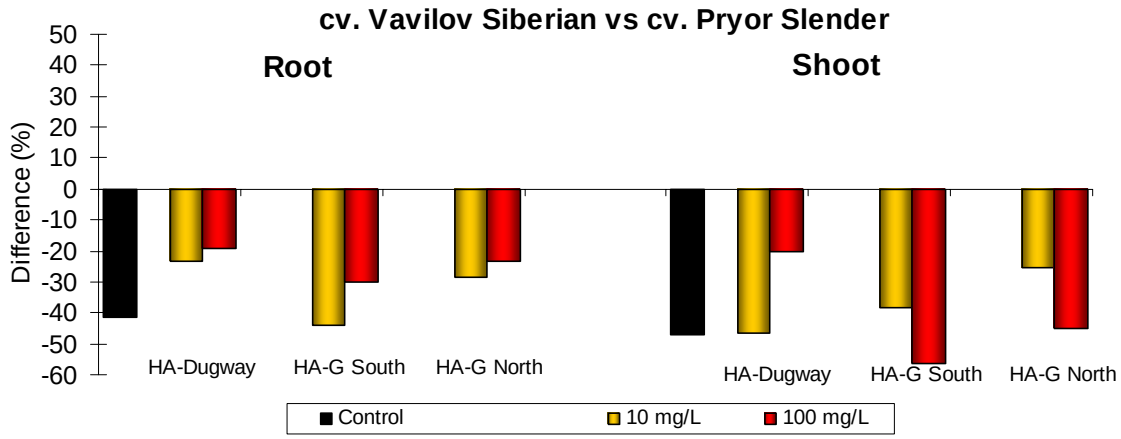


Figure 4. Effect of HAs at different concentrations on the difference (%) of shoot and root fresh weights between the two varieties grown together for 21-days. Top, COMBI-D, middle, COMBI-E, bottom, COMBI-F.





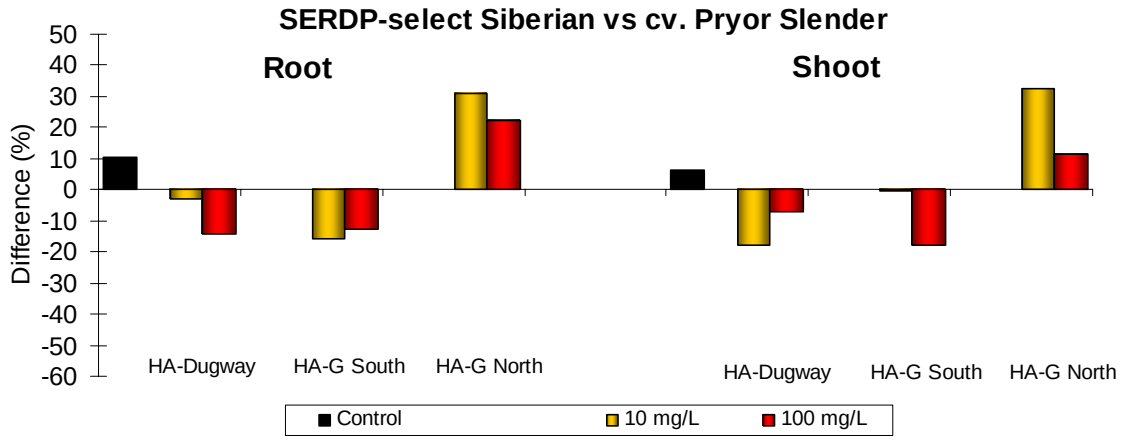


Figure 5. Effect of HAs at different concentrations on the difference (%) of shoot and root dry weights between the two varieties grown together for 21-days. Top, COMBI-D, middle, COMBI-E, bottom, COMBI-F.